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AMERICAN INDUSTRIAL HYGIENE ASSOCIATION QUARTERLY

Volume 8 MARCH, 1947 Number 1

This Issue

Ninth Annual Meeting AIHA

THE WEEK of March 28, 1948, has been set at the date of the Ninth Annual Meeting of the AIHA, to be held in Boston, Massachusetts. Members of the Association and others having material for presentation before this meeting should contact one of the following members of the Program Committee: J. H. Sterner, M. D., Chairman, Eastman Kodak Company, Rochester, New York; D. D. Irish, Dow Chemical Company, Midland, Michigan; W. H. Pierce, Employers' Liability Assurance Corp. Ltd., Boston, Massachusetts; J. J. Bloomfield U. S. Public Health Service, Washington, D. C.

COMMON industrial operations present many solvent vapor exposures in modern industry. FRANK A. PATTY, A.I.H.A President, has outlined the nature of these and methods of control in a practical paper on the subject . . . . SIMPLICITY of method for field evaluation of health hazards is much to be desired. The method described by EGE and SILVERMAN is a step in this direction . . . . CONTROL problems incident to radioactive energy are confronting more of us as its applications broaden. CURTISS provides a sound approach to this much sensationalized subject . . . . THE industrial health program of one of the country's great corporations is a commentary on the importance which management attaches to such a program and the competence of a well-qualified staff in carrying it out.

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AMERICAN
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Solvent Vapor Exposures from Common Industrial Operations

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SOLVENTS may be defined as liquids capable of bringing various materials into solution without chemical change. They may be employed in industry to produce a solution of industrial importance, to distribute another material, or to remove undesirable matter from objects.

The most universal solvent is water with which we are not concerned here. Our interest is confined to those solvents that may cause harmful or dangerous vapors in workroom atmospheres, and are usually referred to as volatile organic solvents. For convenience we will classify the subject by processes.

Metal Degreasing

1. Cold Dipping.

Cold dipping is practiced to a certain extent for the cleaning of various objects such as internal combustion engines and especially for the removal of carbon and resinous binders from pistons. The solvents used may vary from a high flash petroleum distillate to a mixture that includes aliphatic and aromatic chlorinated hydrocarbons, ketones, Cellosolves, creosote, and cresylic acid. No generalities regarding control can be made to apply satisfactorily except that no readily volatile or fast drying solvent should be used without effective mechanical exhaust ventilation if workmen are to be exposed to its vapors for more than a few minutes a day. Skin contact with these materials should be avoided and a face shield should be used to protect the eyes and face.

Under certain conditions covered soak tanks may be used successfully without ventilation and, if as is sometimes the case, the tank has a water solution layer over the surface, that also serves to retard the escape of solvent vapors. Low volatility materials such as mineral spirits and kerosene usually present no inhalation exposure during dipping but the subsequent widely practiced compressed air blow-off operation may produce an objectionable irritant mist unless controlled. Fig. 1 illustrates a simple method of providing ventilation control for the operation of blowing kerosene off small parts. The opening in the drum was one foot square and the volume of exhaust was approximately 200 c.f.m.

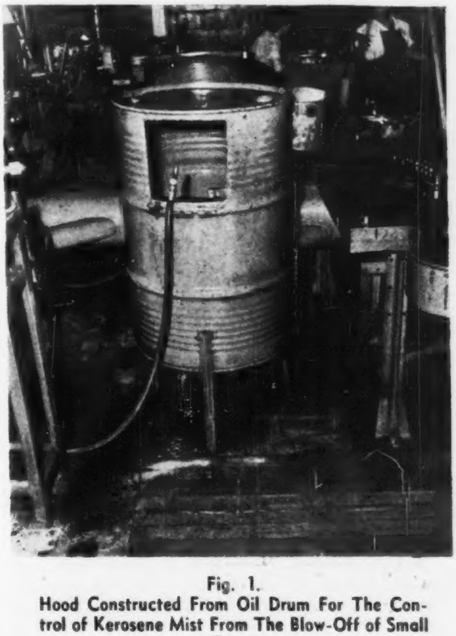

Fig. 1.
Hood Constructed From Oil Drum For The Control of Kerosene Mist From The Blow-Off of Small Parts

Presented before the Industrial Hygiene Session of the Midwest Safety Conference, Chicago.

2. Solvents applied by brushing or wiping.

When solvents kept in a safety can or other suitable covered container are applied in small amounts by brushing or wiping, the inhalation hazard far exceeds any fire hazard. Consequently, where this kind of operation is found necessary, it is usually better to use petroleum distillates, ketones, and esters rather than chlorinated hydrocarbons. If the chlorinated hydrocarbons are found necessary to the operation, it is best to provide exhaust at the point of usage unless the solvent is very sparingly applied. Soldering and brazing operations are often said to require the use of carbon tetrachloride but in nearly all instances it has been found that with the right flux it makes little difference as to what solvent is used or whether any is used on the joint just before soldering.

Where work is conducted without ventilation in small rooms, vats, tanks and the like, volatile organic fluids should never be liberally applied by a swab or brush or used in flat open containers. If it is necessary to use volatile solvents in such situations, fresh air hose masks should be employed for personal respiratory protection. When organic liquid solvents are applied to large surfaces such as car or bus bodies, well engineered ventilation is essential and both the explosion and health angles must be considered.

3. Petroleum solvent sprays.

Spraying with high flash petroleum distillates, such as oleum spirits, mineral spirits or kerosene, is a widely used method of cleaning oils and grease from metal. Solvents with a flash point below 100° F should not be used for this purpose. The operation should always be provided with suitable mechanical exhaust ventilation, preferably a hood as small as practical with exhaust sufficient to control any mist or vapor, at least 100 cubic feet per minute per square foot of hood face. The fire hazard attendant to spraying a high flash petroleum solvent is no more than that attendant to spraying many lacquers and paints.

4. Degreasing machines.

A degreasing machine is essentially a heated chamber in which to boil a grease solvent, space above the boiling solvent for hot solvent vapor, a condenser above this for cooling and condensing the vapor to a liquid state and an extension of the sides above the condenser to minimize air currents inside the machine. The purpose of the condenser is to limit the vapor space above the boiling solvent to a definite height and prevent the escape of the concentrated vapor into the room. The air space above the vapor inside a degreaser contains a vapor-air mixture somewhat richer in solvent vapor nearer the vapor line.

In vapor degreasers the work is lowered into the vapor above the boiling solvent and the solvent condensing upon the cool metal surface dissolves and washes away oil and grease films. If the material is not allowed to remain long enough to reach the temperature of the vapor, considerable solvent will be dragged out with the dripping parts.

Degreasing Solvents

The preferred solvent for water cooled degreasers is trichloroethylene, also called Perm-A-Chlor, Blacosolv, and Triad, but tetrachloroethylene, also called Perm-A-Kleen, and Phill-solv, can be used in these machines after they have been adjusted to suit the characteristics of the higher boiling solvent. The machines not equipped with water cooled condensers are designed to operate with perchloroethylene only and they should not be operated with other more volatile degreasing solvents such as trichloroethylene under any circumstances.

Besides trichloroethylene and tetrachloroethylene, two other solvents have been used in water-cooled degreasers. They are carbon tetrachloride and ethylene dichloride. Carbon tetrachloride because of its volatility, greater toxicity, and susceptibility to hydrolysis into acid is not considered a suitable solvent for degreasing machines. Ethylene dichloride either straight or mixed with trichloroethylene has been used. However it not only involves a considerable toxicity problem common, to some extent, to all chlorinated hydrocarbons but it also is inflammable. It flashes at 56° F by the closed cup method and vapor-air mixtures ranging from 6.2 to 15.9% ethylene dichloride by volume will explode with violence when ignited.

It may be in order here to discuss trichloroethylene and tetrachloroethylene briefly and point out certain characteristics that may have a bearing upon the choice of a degreasing liquid. The boiling points are somewhat different. The parts leaving tetrachloroethylene are too hot to handle but this high temperature may be advantageous to a subsequent operation and the high boiling solvent is said to be more effective in driving moisture from small orifices and crevices. The relatively high boiling point of tetrachloroethylene makes it possible to use it in machines without water cooled condensers. Due to the lower heat of vaporization and higher boiling temperature of tetrachloroethylene, more condensation of vapor results per unit weight of metal to be degreased. These factors are conducive to greater condensation of vapor to liquid and consequently on light gauge material, to more efficient cleaning.

The higher temperatures involved in boiling dirty tetrachloroethylene may be more conducive to pyrolysis or decomposition of the solvent with resultant acid formation.

The lower vapor pressure of tetrachloroethylene limits the amount of vapor that can exist in the air without condensation to about three per cent at 77° F. The density of such a vapor-air mixture (1.1) is frequently of more practical importance to us than is the usually quoted pure vapor density figure of 5.7 which would indicate that any escaping vapors would sink rapidly to the floor. As a matter of fact the concentration of vapors escaping from a degreaser is rarely greater than 2000 parts per million by volume and the density of such a mixture is essentially the same as that of air when the temperatures are the same, but as the temperatures existing above and around an operating degreaser are elevated, always above 110° F, the vapor escaping from the machine is usually lighter than the surrounding air and therefore rises rather than sinks. A 5° F rise in temperature is sufficient to overcome the slightly increased density of a 0.2% (2000 p.p.m.) vapor-air mixture and cause it to rise from the surrounding room atmosphere.

Fatalities have resulted from the use of solvent degreasers. Intoxication results chiefly from inhalation of the vapors. It is doubtful if systemic industrial poisoning results from absorption of these materials through the skin of the hands, but skin irritation as a result of defatting may result from these as from other fat solvents.

PROPERTIES OF TWO DEGREASING SOLVENTS

Property	Trichloroethylene	Tetrachloroethylene
Boiling point °F.	189	250
Heat of vaporization at B.P. Btu/lb	103.1	90.1
Vapor pressure at "room" temperature (77° F.) mm. Hg	76	23
Amount of vapor in "saturated" room air per cent by volume	10	3
Density of vapor at boiling point, (air at same temperature = 1)	4.5	5.7
Density of boiling vapor (air at 77° F. = 1)	3.7	4.3
Density of air saturated with vapor at 77° F. (air = 1)	1.35	1.1
Density of 2000 p.p.m. vapor-air mixture at 77° F. (air = 1)	1.007	1.01
Density of 2000 p.p.m. vapor-air mixture at 110° F. (air at 77° = 1)	0.94	0.94
Toxicity	Moderate	Moderate
Odor	Readily noticeable. Not offensive to most persons	Moderately strong, unattractive Offensive to some persons
Flammability	Difficult to ignite. No violent explosion	Not flammable under any conditions
Ignition temperature	770°F.	Does not ignite.
Temperature (°F.) at which pyrolysis may become significant. Higher temperature should be avoided	248	284

Trichloroethylene at room temperature will not burn but trichloroethylene vapor when heated above 110° F has a narrow flammable range around 20% by volume. This range increases with temperature and above 135° F the flammable range is from about 15 to 40% by volume and the ignition temperature is 770° F. These conditions do not occur in plant atmospheres but may occur within a degreaser.

Trichloroethylene vapors will not explode violently under any circumstances but may burn slowly to form dense smoke and gases such as chlorine, hydrogen chloride and phosgene. Although tetrachloroethylene vapor will not ignite or burn, oils or greases accumulated during cleaning will, and for that reason sources of ignition, especially overheating with gas or electric heaters, should be avoided during distillation for sludge removal. Also welding on or in a degreaser when it contains any solvent should be avoided. Temperatures above 248° F

for trichloroethylene and 284° F for tetrachloroethylene may cause significant decomposition from heat (pyrolysis) and should be avoided, except possibly if necessary during solvent recovery.

Heat Source and Heat Controls

DEGREASERS may be heated by electricity, gas or steam, and steam is usually preferred. All machines should be provided with heat controls for the boiling chamber and have thermostatic controls located a few inches above the normal vapor level to shut off the source of heat if the vapor rises above the condensing surface.

One such control device operates on compressed air. The purpose of a degreaser is to clean metal on a production line and if for any reason this safety steam shut-off valve should close or be blocked with sludge so that sufficient steam for efficient operation is not available to the boiling chamber, production stops. This condition has occurred and so provision has been made for admitting steam for emergency operation until the valve can be cleaned or repaired. As a result many degreasers have been fitted with a by-pass steam line that any one can open by merely turning a valve thus nullifying the safety features of the steam shut-off. It does not appear altogether logical to provide a safety control and at the same time a parallel means of making its action useless. Such by-pass valves might better be locked in the closed position and the key placed in the hands of a responsible person or the line removed and plugged so that the maintenance department's cooperation would be required to open the by-pass.

Ventilation

A PROPERLY constructed and operated degreasing unit located in a room of over 30,000 cubic feet need not require a direct exhaust system and such a system man cause serious solvent loss. Several fatalities have resulted from carelessness during the cleaning of degreasers, but there have been few injuries or fatalities attributed to exposures arising from the normal operation of degreasing equipment. Two fatalities recently attributed to prolonged exposure to trichloro-ethylene vapors arising from a degreasing machine occurred where the degreasers were equipped with direct exhaust systems. This supports the general opinion that individual exhaust systems do not necessarily offer satisfactory control for faulty operating practices. General ventilation is a desirable safeguard. Degreasers should be kept covered when not in use but frequent and abrupt covering and uncovering is more wasteful of solvent than leaving the cover off until the job is finished as it tends to fan the vapors out of the machine. For the conveyorized and enclosed machine a relatively small volume of air exhausted just inside the opening at which the operator stands controls the exposure without materially increasing the solvent loss. Figure 2 illustrates such an arrangement. A considerably greater volume of exhaust correctly applied outside the machine, as shown in Figure 3, is likewise effective solvent loss. A slot at the inside top of an open degreaser offers satisfactory control but may increase solvent loss especially if the volume exceeds 30 c.f.m. per square foot of tank surface.

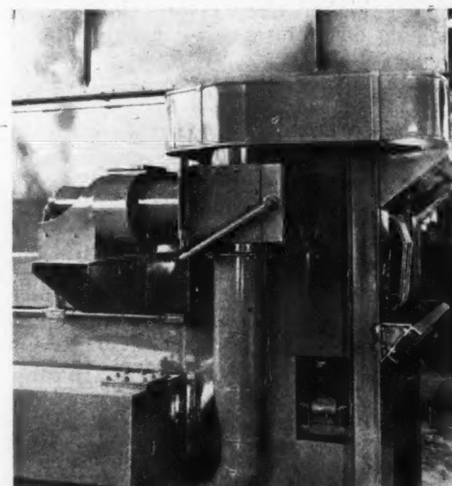

Fig. 2.
Satisfactory Exhaust Hood for Conveyorized Degreaser. Exhaust Applied Just Inside Loading Port

Five general and very common causes of solvent loss and atmospheric contamination may be pointed out:

(1) *Air motion of more than about 50 feet per minute across an open top degreaser especially when directed lengthwise.* Drafts should be eliminated and degreasers should be covered when not in use.

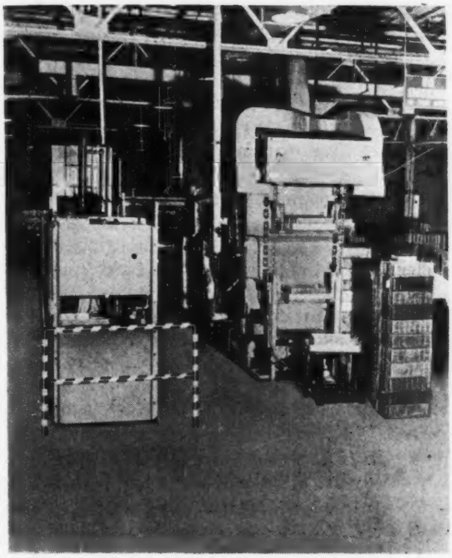

Fig. 3.
Satisfactory Exhaust Hood with Exhaust Applied Outside Loading Port

(2) *Mechanical displacement of solvent vapor.* Overloading may drive vapor out of the machine by physical displacement, especially where there insufficient clearance between the sides of the rack or the work and the machine. Also, when the load is great in relation to the heat input, it will cool and condense so much vapor as to cause the vapor level to fall and draw air into the degreaser.

The area above the vapor level in a degreaser is filled with a more or less rich solvent-air mixture. When the vapor level is lowered, the volume of this vapor-air mixture is increased by drawing in room air and when the level is brought back to normal some of the mixture is forced out into the room. The heat input should be sufficient to prevent the vapor line falling below the bottom of the condenser under maximum load.

Machines not equipped with water condensers but equipped only with bimetallic thermostats placed well up on the side of the machine may displace an appreciable volume of vapor-air mixture each time the vapor rises to the thermostat. Where the change of vapor level exceeds six or eight inches in the normal operation of the machine, excessive air contamination will result.

(3) *Improper operation of condenser.* All too frequently, exposures can be traced to failure to open the valve to start the condenser operating before heat is applied to the boiling compartment. It is also a mistake to turn too much water through the condenser. The effluent water should never be below room temperature and may safely range up to 110° F with trichloroethylene and 150° F with tetrachloroethylene.

The control of the temperature of the condenser should not be left to guess work, but the water flow should be adjusted by a key valve or other means to give the correct temperature reading on an indicator and the water turned on full at the shut-off valve. This adjustment should be made either for the minimum temperature while operating under full load or for maximum while idling. It is desirable practice to provide a safety control to make it impossible to heat the boiling chamber before water is turned on in the condenser.

(4) *Speed of Work.* One of the hardest things to control on hand-operated open-top machines is the speed of the work, which ordinarily should not exceed 11 or 12 feet per minute while work is being lowered into or raised out of the machine, as well as when work is moved within it. Speeds above this may displace vapor or mix it with air by agitation.

(5) *Carry out.* The work should always remain in the vapor until it appears dry, otherwise liquid solvent will be carried out to evaporate in the room air. Absorbents such as rope, cloth or wood should not be a part of the work degreased or a part of the rack or hoist. Solvent may also be carried out in tubes, cups, intricate shapes and recesses. This kind of work should be racked at an angle or should be tilted or rotated in the vapor zone until all liquid has been drained out.

Miscellaneous Solvent Exposures

Cements: The manufacture and use of cements containing organic solvents involves situations that may become seriously harmful exposures, dependent in extent upon the amount and kind of solvents and the conditions of their use. Cements in use evaporate more or less completely to dryness soon after they are applied.

Chlorinated solvents in cutting oils:

Chlorinated solvents such as carbon tetrachloride are sometimes added to cutting oils to improve the bite in high speed metal cutting operations. Carbon tetrachloride is sometimes added to cutting oils in amounts as high as 20% for use in broaching operations. Obviously the best hygienic control is to leave the solvent out of the oil, but where the process requires it or, more to the point, where the process engineer demands its addition it is usually necessary to provide mechanical exhaust ventilation for the cutting operation. It may even be necessary to control vapor escaping from oil that accumulates on chips or from spillage or leakage.

Drug and chemical manufacture: In the manufacture of drugs and chemicals huge quantities of volatile solvents are used for extraction and other purposes. Experience has shown the necessity for the use of covered containers and enclosed pocesses along with well engineered ventilation.

Dry cleaning: In dry cleaning operations, a choice is ordinarily made between a flammable fluid and a nonflammable one and the control procedures are planned accordingly. The use of a mixture of a flammable solvent along with carbon tetrachloride as a fire-proofing agent is not always dependable. One of the larger department stores found that out the hard way. They cleaned some hats in a mixture of 30% high-boiling petroleum distillate and 70% carbon tetrachloride and then put the hats in a poorly vented gas-fired oven to dry. The carbon tetrachloride evaporated first leaving the less volatile petroleum solvent, the vapors of which filled the oven and exploded, causing a fire and serious personal injury.

Filling containers: When filling containers such as cans and drums with solvent or mixtures containing solvents, there may be an excessive exposure unless good ventilation control is provided. When a drum is filled with any volatile liquid, the first liquid entering the drum serves to saturate the air in the drum with solvent vapor and as the drum is filled this vapor-air mixture is all displaced into the room. The amount of saturated solvent vapor-air mixture to be reckoned with then becomes a matter of the capacity of each container times the number filled per unit of time.

Leather manufacture: In leather manufacture the hides are sometimes treated with a mixture of a solvent, such as ethyl acetate, and neatsfoot oil. There is an exposure during application that requires ventilation control and a greater potential exposure where the hides are hung on racks to dry.

Painting exposures: In painting there are, in addition to exposures to pigments, exposures to solvent vapors and mists. In spray painting objects inside booths while the workman is standing outside, these exposures are relatively easily controlled by ventilation; but when the workman is stationed inside the booth, control becomes a serious engineering problem and, unless the direction of air flow and direction of spray can be maintained more or less parallel, with sufficient air flow to control rebound and eddy currents, personal respiratory protection is required. The larger the object to be painted, the more difficult the control problem. Drying of painted objects must be accompanied by suitable ventilation because obviously all solvent must be more or less completely evaporated before the paint can become dry.

Paint thinners: Paint thinners have a widely variable composition. The vapors of all of them are toxic, varying only in degree and I should like to take exception to a statement recently attributed to a responsible man in the paint manufacturing business. The statement was that the lacquer industry would get a very valuable boon were a relatively inexpensive, odorless, yet powerful solvent developed, and that there is a great need for a really odorless thinner or a thinner with an odor generally recognized as pleasant or fruity. I should like to point out that the greatest safeguard from the standpoint of health and safety are the odor and eye or nasal irritation caused by solvent vapors. Were it not for these warning properties, there would be many times as many explosions and occupational diseases resulting from excessive amounts of solvent vapor escaping into workroom atmospheres, and this particular research chemist's dream would be a ferrible boomerang. So let's hope that this bit of research proves fruitless.

Paint and varnish removers: Paint and varnish removers usually contain very volatile and sometimes very toxic solvents and, although they also contain waxes to retard evaporation, so far as solvent vapor exposures are concerned, the exposure is dependent upon the amount of remover applied, the ventilation rate, and the size of the room.

In addition to the foregoing, there are numerous additional specific exposures such as are encountered in the rubber industry, plastics manufacture and use, ink manufacture, printing and photo-engraving, waxes and polishes, and the manufacture and use of coating materials.

Estimating the Exposures

The surest way of evaluating an exposure to solvent vapor is to call in a qualified industrial hygienist. Such service can usual'y be obtained promptly and free of charge from the city or State official agencies, from your insurance carrier if you are insured by a progressive company, or from private consultants. However there are certain facts which if carefully considered will avert the necessity of frequent visits of this nature.

(1) *Vapor pressure.* The amount of solvent vapor that can accumulate in the air is limited by its vapor pressure. Atmospheric pressure at sea level is equivalent to a column of mercury 29.92 inches or, as usually stated, 760 mm. in height. All liquids have a vapor pressure somewhere between 0 and 760 mm. and this vapor pressure limits the maximum amount that can get into the air. For instance, if a solvent has a vapor pressure of 7.6 mm. at 70°, the most vapor that could accumulate in the atmosphere at that temperature would be 7.6 divided by 760 or one per cent. Vapor pressure then is the most important property governing the degree of an exposure. Temperature is another factor because elevation of the temperature raises the vapor pressure.

(2) *Surface area.* Next in importance is the surface area of the solvent in contact with the room air — the greater the surface the more nearly the air becomes saturated or approaches the limit set by the vapor pressure of the solvent.

(3) *Toxicity.* Another very important factor in the harmfulness of a solvent vapor exposure is the toxicity of the solvent. This ranges in degrees from the moderate'y toxic ethyl alcohol, acetone and ethyl acetate which can be inhaled all day, day in and day out, in concentrations of around 400 to 600 p.p.m. without injurious effects, to some of the more toxic, and insidious delayed action solvents, such as tetrachloroethane with a permissib'e limit of only 10 p.p.m.

(4) *Flammability.* The flash point and lower flammable limit are of prime importance in estimating and avoiding vapor explosion hazards.

(5) *Ventilation.* On the right side of the ledger is your ventilation. Not only the volume of air moved into and out of the room is important but, often of greater importance, correctly engineered process ventilation, which can frequently be arranged to control the direction of air flow in such a manner as to practically prevent any vapor coming in contact with workmen.

For those who are interested in computing the volume of solvent vapor formed by the evaporation of a known weight of solvent, the following formula may prove useful:

Cu. ft. solvent vapor at 77°F (25° C) and 760 mm. Hg. =

$$\frac{\text{lbs. solvent} \times 392}{\text{molecular weight of solvent}}$$

Given the cubic feet of vapor, the volume of air necessary to dilute it to any required level of p.p.m. is readily computed. If the rate of evaporation is known the rate of dilution or general ventilation requirements is also easily computed.

St. Louis Section

On February 17, 1947, the subject "Newer Trends in the Diagnosis and Treatment of Lead Intoxication" was introduced by Wm. G. Wood, M. D., Physician with the Lead and Oil Products Plant of the National Lead Company. Mr. R. V. E. Martin, Superintendent of the Oil Works, discussed the environmental control procedures which have been instituted by this company at this plant. Mr. H. W. Schrick, Personnel Director described the nutrition and educational approach made by the company in combating excessive lead absorption.

Efficiency of Filter Paper and Impingers for Chromic Acid Mists in Air

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In a recent article[1] we described the development of a rapid method for the determination of chromic acid mists in air. It was necessary in the course of this investigation to ascertain the efficiency of filter papers for the collection of these mists since, to our knowledge, no data were extant. Zhitkova[2] reported the use of filter papers for this purpose and states that the air is drawn through a "fine filter paper" mounted in a porcelain funnel at a rate of 10 to 15 liters per hour. No efficiency data are given, but he says "this method shows traces of chromium compounds from electroplating baths when usual absorbers show nothing." Ficklen[3] recommends this method with an 11 cm. Whatman No. 42 paper mounted so that a 10 cm. diameter is exposed. Sampling is at a rate of 1 liter per minute for 20 minutes. The only other filtration procedure described is that of Akatsuka and Fairhall[4] who utilize cotton plugs soaked in glycerine for sampling chromium dusts in air.

The use of filter papers for sampling acid mists is not new, however, since Weber,[5] in an early article, reports the use of filter papers for sampling sulfuric acid mists, but he gives no absolute efficiencies.

Efficiency of Filter Papers

Method. In developing a rapid field method for chromic acid[1] we used the welding fume hand pump[6] with a heavy absorbent paper. This paper appeared to be the most satisfactory for retention of mists as well as the paper impregnating agents. This sampling pump has an exposed paper diameter of 0.95 inches. A uniform rate of sampling consists of one stroke in 0.026 minutes, which is equivalent to an air flow rate of 0.82 c.f.m. (This corresponds to a filter approach velocity of 134 f.p.m.) The efficiency of the filter papers was therefore tested at flows approximately this value.

The filter papers were clamped in a small pair of funnel-like cones and were connected in series with a large impinger containing 75 ml. of distilled water. At flow rates less than 1 c.f.m. uncontaminated air was bled into the impinger supply to maintain its rate at 1 c.f.m. while the flow through the filter was held at the desired rate. Unpublished results[7] obtained in this laboratory indicate that the large impinger efficiency is over 95% when distilled water is employed as a collecting medium and a D.C. electrostatic precipitator is used for a reference standard.

Chromic acid mists were generated continuously by a nebulizer and air flow system described previously.[1] The filter papers and impinger were analyzed with a stable s-diphenyl carbazide reagent.[8] Papers were washed well with distilled water and analyzed directly — an aliquot of the impinger was analyzed similarly. If filter papers are used for field sampling and allowed to stand for any period before analysis it is necessary to oxidize the sample to hexavalent chromium before analysis.

RESULTS. The experimental results for the mist efficiency or filter papers are given in Table 1 and Table 2. Table 1 presents the relative efficiency data for four filter papers connected in series and indicates that this paper is very efficient for mist collection. The absolute efficiencies, using the impinger as a standard, are indicated in Table 2. Here the effect of rate and concentration are also shown, but neither of these factors appears to exert any influence upon the effiency which is almost 100%.

Efficiency of Impinger

The filter paper tests indicate almost complete collection; hence, it is interesting to reverse the sampling order and determine the efficiency of the large

1. Present address Mutual Chemical Company of America, 1348 Block Street, Baltimore, Maryland.

*A portion of this material was presented before the New England Section, American Industrial Hygiene Association, Boston.

TABLE 1.
RELATIVE EFFICIENCY OF FILTER PAPERS FOR THE COLLECTION OF CHROMIC ACID MISTS (E.&D. NO. 623 PAPERS—0.95" EXPOSED DIAMETER AT 1 C.F.M.)

Concentration mgs/10 cu.m.	Amount Collected Paper Number 1 Gamma	2 Gamma	3 Gamma	4 Gamma	Efficiency %
30.4	1334	0.4	0.4	0.2	99.9
26.2	1150	0.9	1.0	0.4	99.9
27.2	1267	0.7	1.0	0.8	99.9
					Mean 99.9

impinger relative to the filter paper. These data are shown in Table 3 for several mist concentrations. It is observed that the filter paper is a more efficient collection method than the impinger although the efficiency obtained with the latter method is high and does not alter, significantly, the results of Table 2.

TABLE 2.
ABSOLUTE EFFICIENCY OF FILTER PAPERS FOR CHROMIC ACID MIST (E.&D. NO. 623 FILTER PAPERS USING LARGE IMPINGER AT 1 C.F.M.—75 ML. DISTILLED WATER AS STANDARD)

Sampling rate c.f.m.	Concentration mgs/10 cu.m.	Amount Collected Paper Gamma	Impinger Gamma	Efficiency %	Mean %
0.25	19.8	140	0.1	99.9	Mean
0.25	14.1	100	0.9	99.1	99.5
0.50	10.3	145	1.2	99.2	
0.50	9.6	135	0.9	99.3	99.3
0.75	9.9	210	0.4	99.8	
0.75	9.5	200	1.4	99.4	99.6
1.0	1.7	70	0.05	99.9	
1.0	1.7	70	0.05	99.9	
1.0	9.2	260	0	100	
1.0	10.6	300	0.1	99.9	
1.0	29.7	840	2.5	99.7	
1.0	31.6	890	2.5	99.8	99.9

Discussion

THE above data indicate that absorbent filter papers may be used for efficient collection of chromic acid mists in air. With a sensitive analytical method a hand pump may be employed and the filter discs are then analyzed in the laboratory. A rapid method, using impregnated filter papers described elsewhere[8] permits direct analysis in the field.

The use of filter papers in field sampling for chromic acid mists reduces the amount of equipment necessary for obtaining air samples in plating shops and other chromic acid exposures.

The efficiency of the filter paper method for chromic acid mists is high and uniform and comparable to any method now in use.

TABLE 3.
EFFICIENCY OF IMPINGER RELATIVE TO FILTER [LARGE IMPINGER—75 ML. OF DISTILLED WATER —1 C.F.M. FOLLOWED BY A CIRCLE OF E.&D. NO. 623 FILTER PAPER (EXPOSED DIAM. 0.95")]

Concentration Mgs/10 cu.m.	Amount Collected Impinger Gamma	Paper Gamma	Efficiency %
2.1	80	7	92.0
3.1	140	5	96.6
3.3	110	4	96.5
8.2	220	11.4	95.4
9.7	260	13.5	95.7
34.6	1000	33.5	96.9
35.7	983	27.5	97.3
			Mean 95.8

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New Jersey Section

ON FEBRUARY 20, Dr. Harvey C. Rentschler, Director of Research, Lamp Division, Westinghouse Electric Corporation, addressed the Section in Newark on the subject "Health and Safety Factors for Radiant Energy and Radio-Active Materials."

Pittsburgh Section

THE general subject of ventilation was discussed by Mr. T. F. Hatch of the Industrial Hygiene Foundation of America on January 14 at the U. S. Bureau of Mines.

Current and Future Environmental Control Problems Attendant on the Use of Radioactive Energy

L. F. CURTISS,
Chief, Radioactivity Section,
National Bureau of Standards, Washington, D. C.

THE publication of the Smyth report on atomic energy for military purposes has released considerable speculation regarding the problems of protecting personnel in the anticipated industrial uses of the processes developed in connection with the atom bomb. Fortunately this report is surprisingly complete and enumerates the types of industrial hazards of radioactive origin which were encountered, in addition to outlining the general methods used in providing ample factors of safety in every situation.

The Smyth report is replete with references to radioactivity of intensities never previously encountered. It summarizes the types of radiations from which protection is required under neutrons, alpha, beta, and gamma rays. From the fact that these radiations are already familiar to physicists, chemists and safety engineers we can conclude that the problems of protection are those of degree and do not require the application of any radically new principles. Combining the information available in the Smyth report with that generally available we can construct an approximate picture of the protective measures which will be required in the future peace time applications of nuclear energy.

The future industrial importance of the applications of nuclear energy is not questioned by anyone familiar with the subject. There is difference of opinion only on how rapidly this application will develop. Naturally the speed with which nuclear processes are applied commercially will depend on many factors not inherent in the engineering and financial aspects of the undertaking. Among these factors are the types of supervision and control imposed by our government and my international agreement. Nor can all the possible industrial applications be predicted although from the general situation it is certain that the production of various radioactive isotopes for use as tracers and as therapeutic agents in medical and biological treatment and research will expand rapidly. Industrial use of radioactive tracers will also be applied to an increasing number of problems. The enormous potentialities for production of power for various industrial uses from nuclear energy may take some time to reach a profitable development since, at present, the cost is high and the equipment is of considerable weight and bulk. Additional information from peacetime research in this field will be required to eliminate these obstacles. But above all, before widespread industrial expansion can be expected, safe methods for carrying out the processes involving intense radioactivity must be available as well as health inspectors trained to deal with these new problems.

Presented before the Seventh Annual Meeting, American Industrial Hygiene Association, Chicago.

The Radiation Problem of Nuclear Energy

TO ASSESS the relative importance of the problems of protection from radiation it is helpful to review the various steps and processes which lead up to the release of nuclear energy in atomic fission. This reaction occurs, as far as is known at present, to an important degree only in thorium, uranium and plutonium. The information already released in the Smyth report reveals the nature of the problems of protection encountered in assembling these substances in a form to produce a self-sustaining nuclear reaction with the continuous liberation of energy from fission. Natural uranium has been found to be well suited to such a liberation of energy when assembled in a pile consisting of purified uranium metal and a graphite or similar moderator. Plutonium and still unknown artificially produced elements may, in the future, play an equally important role in chain reactions for production of neutrons, transmutation of elements and the production of energy.

Uranium is a relatively inactive substance radioactively and the problems connected with its mining and refining are well known since for years uranium ores have been refined for the radium which they contain. This radium must still be removed in the procurement of uranium for the construction of piles and its recovery still presents the chief hazard in this stage of the process.

As soon as the uranium has been assembled in the form of a pile the intense radioactivities mentioned in the Smyth report, as well as similar intensities of both fast and slow neutrons, are developed. The various nuclear processes that proceed simultaneously comprise, in addition to the nuclear fission, the capture of neutrons by various elements in the pile which results in the production of artificially radioactive isotopes. It is generally known that wherever an atom captures a neutron very energetic gamma rays are released. Therefore we have in a pile a combined source of neutrons, alpha, beta, and gamma rays. The gamma rays are moreover in many instances of higher energy and therefore more penetrating than the gamma rays from radium. This factor is known from studies of the energy of the gamma rays from artificially radioactive isotopes produced in cyclotrons in the period before the war. Therefore, the pile itself must be shielded so that none of this radiation can escape. Furthermore, as the Smyth report indicates, no gases can be permitted to escape into working areas since many of these, even those present in small traces in the atmosphere, may have become radioactive when subjected to the high intensity of neutrons existing in the pile. Fortunately, enough general information is available to permit us to predict quite accurately the type of shielding required. It will be in every way similar to that used around cyclotrons and other "atom smashers" which exist in considerable numbers about the country. The almost uniform practice now is to utilize concrete to cut out the gamma rays, and moist concrete or similar substance containing water to cut off the neutrons, particularly the neutrons with high energy. Slow neutrons can be stopped readily with relatively thin layers of such materials as cadmium or boron. Most ordinary materials contain other elements which similarly reduce the intensity of slow neutrons to a very low value, in layers of a few inches. Since in the design of piles as few neutrons as possible are permitted to escape to the shield, the requirements are not particularly severe as far as screening the neutrons is concerned. Several feet of concrete may be required, on the other hand, to absorb the gamma rays and the fast neutrons.

Since in the operation of the pile there is always opportunity for the escape of neutrons through openings used for introduction of fresh materials and removal of products, considerable attention must be given to maintaining exposures below a safe level. This problem again has been encountered in the operation of cyclotrons, so that devices for detecting safe levels, the determination of what level is safe and protective measures are already available. In dealing with neutrons, it is necessary to classify them as fast or slow because of the peculiarly different effects of the two types. Slow neutrons are those which have velocities approximately equal to those of thermal agitation of the surrounding material or gas. Fast neutrons are those which have velocities in a very wide range above this value. The outstanding difference is that slow neutrons readily attach themselves to the neucleus of some nearby atom and transform it into a new isotope which is almost invariably radioactive. Fast neutrons on the other hand produce little effect unless they collide head on with a nucleus. Even so, they do not lose much energy unless the nucleus has a mass equal to that of the neutron, in other words the nucleus is that of the hydrogen atom. The hydrogen nucleus is transformed in the collision into a proton which may have considerable energy and has a high specific ionization.

In estimating the effects of these two types of neutrons on the body we can see at once they will be very different. The slow neutrons will produce bodily effects chiefly by causing the superficial layers of the body to become temporarily radioactive, thereby irradiating the rest of the body with beta and gamma rays.

The fast neutrons will produce protons in all parts of the body and the protons in turn will, because of their relatively strong ionizing power, produce destructive effects in the body tissue. Since neither type of neutron has a charge, neutrons themselves produce no ionization and have no direct effect on the body.

Protective Measurements

MEASUREMENTS must be made of each type of radiation to ascertain that they are maintained below safe limits. In fact it is desirable to maintain conditions so that the combined effects of the various radiations do not exceed the reasonably safe limit for any one. Adopting this view, the problem of protective measurements for gamma rays and slow neutrons becomes fairly simple. We have seen that slow neutrons merely add to the gamma ray exposure by producing gamma radiation in the surface layers of the body. They may also raise the level of gamma radiation by being absorbed in surrounding objects. Therefor it is only necessary to make measurements of the daily exposure to gamma radiation to ascertain the combined effects. These measurements are conveniently made by use of pocket ionization meters of the Victoreen type. These are carried by the worker throughout his tasks and checked at the end of the work period. It is also desirable to supplement the pocket chambers by use of photographic film, such as x-ray dental film. These films can integrate exposures over longer periods than one day when used under carefully controlled conditions will detect excessive exposures in the longer period.

Fast neutrons must be measured in an ionization chamber which has walls containing hydrogen so that the protons ejected from the walls will produce an ionization of the gas. It would be preferable to have chambers with a hydrogen content approximately equal to that of the body. However, a practical compromise can be made to achieve the correct result. For example, the Victoreen minometer equipped with a 100 r chamber has a bakelite wall containing sufficient hydrogen to make measurements of fast neutrons practicable. If we designate a reading as 1 r when the meter gives the same reading for neutrons as for 1 r of gamma rays and then set the tolerance for fast neutrons at 0.01 r instead of the usual 0.1 for gamma rays for an 8 hour day, we then compensate both for the lower sensitivity of the meter and the increased biological effectiveness of the fast neutrons when compared with gamma rays. It is obvious that pocket meters cannot be devised conveniently for fast neutrons. Monitoring instruments must be used to make surveys to ascertain that the intensities of these fast neutrons are kept below the tolerance. Measurements of gamma radiation must be made simultaneously so that the reading of the neutron meter may be corrected for the effect of the gamma rays on the instrument.

The only remaining types of radiation to consider are alpha and beta rays. The possible injuries and protective measures for these two types of radiations will, of course, differ only from past experience because of the intensity of the sources of these radiations which will be encountered. Alpha rays in the past have proven injurious only when the source has been introduced into the body. This results in an internal poisoning exemplified by radium poisoning in the radium dial painting industry. This type of injury is greatly intensified when the body tends to retain and localize the source of alpha rays, as it does in the case of radium. As the Smyth report indicates, the problem here is entirely similar to that encountered in dial painting. Substances which emit alpha particles must not be distributed in the workroom air where they may be inhaled and great care must be taken to prevent accidental ingestion of such substances. Scrupulous cleanliness is required here as in the dial painting industry.

Beta rays occupy an intermediate position, so far as penetrating power is concerned, between alpha and gamma rays. In the presence of intense sources of beta radiation care must be exercised to prevent local burns which may be of some millimeters in depth. Beta rays should be measured with a thin-walled ionization chamber or Geiger-Müller counter and the intensity corrected for

absorption in the wall of the detector. The determination of the tolerance dose of beta particles is complicated by the fact that beta rays of different energies have ionizing power. From a knowledge of the number N of beta particles striking a square cm of surface and their specific ionization K, the dose per sq. cm. can be computed in r. Since r is one electrostatic unit of charge per cubic centimeter it is simply Nke where e is the elementary charge on an ion. For average conditions five thousand beta rays per square cm will give a dose of about .0001 r per square cm. The total dose would be obtained by multiplying by the area exposed to this intensity. In the past, beta ray exposures have usually been localized but conditions may well exist in the future where the whole surface of the body is exposed. Therefore, the total dosage may be large. However, it should be noted that there is no justification for assuming that the tolerance level for whole body exposure to beta rays is 0.1 r per eight hour day as for gamma rays. It may well be that a higher dosage can be tolerated because of the lower penetrating power of the beta rays. Information on this subject is lacking at present.

Medical Aspects of the Radiation Problem

The medical aspects of the radiation problem, from the standpoint of protection, may be considered as practically non-existent. They can be divided in two hypothetical groups. One is concerned with the treatment of radiation injuries. It is the aim of the safety engineer to prevent such injuries and in this case he can be completely successful. Therefore there will be no injuries of this kind requiring treatment. The Smyth report underscores this result. The second of the hypothetical groups involves biological tests to detect incipient injuries. The history of the atom bomb project confirms what has long been suspected, that under properly controlled conditions there are at present no biological tests which can detect exposure to radiation before this exposure has resulted in definite, and perhaps permanent, injury. Blood counts and all similar methods will reveal no vital information under conditions of adequate protection. Measurements of the radiation exposure reveal the approach to unsafe conditions long before they reach the dangerous level.

There is left for the attention of a medical officer only a general health inspection, such as might be given an employe engaged in any work. This health inspection is more important for workers exposed to radiactivity, particularly the preemployment examination. To avoid complications which may arise from claims of ill health caused by radioactive exposure, it is important to exclude from such exposure all persons who suffer from any minor ailment which might be susceptible to aggravation by such exposure, or which might be falsely attributed to exposure to radiation. A continuous case history of employees is advisable for the same reasons.

Remote Controls

As is well known, the inverse square law provides the best protection from radiation. This factor can be used to great advantage in handling radioactive materials which have been removed from piles. Although screens of concrete or water, or a combination of the two, will reduce gamma ray and neutron intensities to safe levels they cannot always be used. Even in cases where they can be employed the operator must control operations from outside the shield. Therefor it is to be anticipated that devices for performing manipulations of strong radioactive sources, which are operated at some distance from the sources, will find increasing use. In many cases their use will be imperative. Such devices must be designed to work efficiently, accurately, and without increasing the time of exposure in those situations where the exposure may be somewhat above tolerance. They must be tested on "dry" runs to insure that they completely fulfill the requirements. Most chemical treatment of radioactive isotopes in large quantities must be carried out by remote control.

Supervision

EXPERIENCE has shown that safety measures, particularly those designed to protect personnel from radioactivity only achieve their purpose under continuous supervision by individuals trained to understand the nature of the problems. Whereas every employee should be instructed in regard to the type of hazard encountered it is only by trained supervision that full compliance can be obtained. Paradoxically enough, it is sometimes the expert who violates protective rules. Supervision is required also to maintain proper housekeeping conditions. Housekeeping involves not only general neatness but also routine surveys to detect radioactive contamination, superintend its removal and determine and eliminate the cause.

It is clear, therefore, that in the future the safety engineer and the health inspector must have a definite place in the organization operating these intense source of radiation. Inspections and control measurements must be made daily to achieve a perfect safety record.

Summary

IN CONCLUSION, we can say that no new types of radiation are to be anticipated in the development of industrial uses of nuclear energy, as far as is known at present. The radiations will be of much higher intensity than any encountered in the past. However, as the Smyth report makes very clear, protective measures can be devised which render these processes as safe, and perhaps much safer, than the industrial operations involving radioactivity have been in the past. These measures will involve methods and instruments already familiar to workers in the field of radioactivity and nuclear physics. In the future these methods must be applied more scrupulously than they have been in the past. Provided this is done, we have every assurance that every operation will be safe. To quote from the Smyth report: "Factors of safety used in plant design and operation are so great that the hazards of the home and the family car are far greater than those arising from the plant." This should be reassuring to industrial concerns who may contemplate entering this field and serve to speed the conversion of processes developed to provide a lethal weapon to peace time uses. With this conversion a considerable responsibility will be placed on safety engineers and health inspectors to make certain that the information available is utilized to achieve the safe conditions which are readily attainable.

Metropolitan New York Section

THE Use and Calibration of the Interferometer in the Field of Industrial Hygiene" were discussed by Dr. Robert F. Stamm, Physicist, and William R. Bradley, Industrial Hygienist, American Cyanamid Company, on January 30, 1947. Data concerning the instrument's usefulness with over 40 different compounds were presented. Information was given concerning the possible development of a modified, portable interferometer for use in evaluating atmospheric contaminants that may be found in industrial environments. The speakers, who have had experience with the use of the interferometer in the investigation and study of industrial health hazards, demonstrated in the instrument at the meeting.

An afternoon meeting was held on February 20 at the American Museum of Natural History. The following program was presented:

1. "Recent Observations on the Thermal Exchange of Man" — Dr. Willard Machle, Consultant, Ethyl Corporation, New York, New York.
2. "Observations on the Volatility of Mercury" — Merril Eisenbud, Industrial Hygienist, Liberty Mutual Insurance Company, New York.
3. "Acute Poisoning from Exposure to Chlorotoluidine"—Dr. L. Holland Whitney, Medical Director, American Home Products Corporation, New York.
4. "Proper and Improper Use of Fans" — Jack Baliff Industrial Hygiene Mechanical Engineer, New York State Department of Labor, Division of Industrial Hygiene and Safety Standards, New York.

Washington-Baltimore Section

DR. W. E. FLEISCHER of the Rustless Iron and Steel Corporation will address the Section on "An Industrial Medical Program" on April 11. Prior to the address, opportunity is to be afforded for a visit through the plant of this concern to observe operations and note measures for control of industrial health hazards.

Industrial Health Program

International Harvester Company

INTRODUCING a presentation of the comprehensive industrial health program of the International Harvester Company by members of the coordinating departments, Dr. Harold H. Steinberg, Harvester Medical Department and president of the Chicago Section, American Industrial Hygiene Association, outlined the magnitude of the problem where the employed group includes a total of 88,000 employees, with roughly 30,000 in the Greater Chicago area.

Dr. Steinberg observed that the plant Medical Departments attempt to accord to every worker the attention he would receive as a private patient. Where the physical examination may disclose some anatomic or systemic disability, this is taken into account in recommending placement in the type of jobs to which the worker is best fitted.

In the field of preventive medicine, such immunization procedures as may be indicated are undertaken. Workers are informed about public health facilities for such diseases as tuberculosis, venereal disease, and cancer. Early detection for reduction in incidence of degenerative diseases, such as those affecting the cardio-vascular system and the gastro-intestinal tract, is of importance in an industrial health program.

Much progress has been made in job placement of the physically handicapped as outlined by Clark Bridges, Kuh, and Hanman. Harvester wishes to go even further in its application of advanced methods for more effective utilization of its employees.

The International Harvester Company has long been interested in industrial health development, and the contributions of the several collaborating departments constitute a constructive program in this integral phase of employer-employee relationships.

Pre-employment Physical Examination

DR. C. W. SCRUGGS, physician in charge at the Wisconsin Steel Works gave the following discussion of the pre-employment physical examination program.

'We consider the pre-employment physical examination and history an important part of acclimating a prospective employee to becoming a member of the Harvester Company. To attain this end we attempt to maintain a friendly but efficient attitude toward the examinee and to impress upon him that the purpose of the examination is to hire the man and not to reject him. Secondary considerations, which I will take up in detail later, are those of attempting to fit a man with a disability to a job which he can safely perform without hazard to his own health and to his fellow employees. To accomplish this our doctors must know the job classifications and the operations of each job in the mill, at least in a general way.

'In carrying out the routine of the pre-employment machinery the man is interviewed in the employment office and special interviews or tests are assigned by departments for which he is designated. He is then sent back to the Medical Department where the nurse obtains a brief family and personal medical history, makes vision and hearing tests, records temperature pulse, respiration, blood pressure, height and weight. A chest x-ray film is taken and blood serology is done.

'He is then turned over to the physician who does a complete physical examination on the completely unclothed patient. A rectal examination is routine on all males over 40. A urinalysis is performed and special examinations such as more extensive neurological examination is conducted if indicated. Female prospective employees are examined in the presence of a nurse and with appropriate draping. At the conclusion of the examination, after the urinalysis has been completed and the chest plate read, the man is referred back to the employment office where his records are kept and he is assigned the date on which to start work.

'We have adopted the following classifications which are simply arbitrary standards to help us maintain control over the employee after he has left our hands. The men are coded in classes of A, B, and C. The class-A man is one who has no physical defect sufficient to interfere with his placement on any operation in the plant. He is subject only to our routine periodic re-examinations. A class-B man is one who has a physical defect such as a hernia, impaired vision or a compensated heart lesion. This means that this man has been approved by the Medical Department for a certain job,

Presented before the Chicago Section, American Industrial Hygiene Association.

but may not be transferred without contacting the Medical Department to evaluate his ability to perform any other job. A class-C man is a reject for all practical purposes. Our regulations as far as coding men B or C are flexible and we have attempted over a period of years to adopt causes for rejection which, on the basis of experience we know to be such that a man's condition will be aggravated by steel mill work or that he will make an inefficient employee.

'A few of our causes for rejection of a prospective employee for steel mill work will be of interest.

'*Hypertension*: We usually consider an employee a poor risk when his blood pressure is over 180 systolic and 110 diastolic. Exceptions may be made to this regulation.

'*Vision*: Providing the man is not designated for close work such as micrometer reading, we have learned to ignore close vision. For distant vision we will accept a man who is able to correct to 20/100 or better. If a man is industrially blind in one eye, the job is considered carefully and he is required to wear cup goggles to protect his good eye. Depth perception and color tests should be required for certain operations, as truck drivers and crane men.

'*Heart*: Heart cases are accepted if we can consider them a good five-year risk, which means that they must be well compensated and have no history of previous congestive failure.

'*Lungs*: We have attempted to learn the type of lung pathology which may give rise to trouble. We consider any case of arrested tuberculosis a poor candidate for work in a steel mill. There are exceptions to the rule depending on the job. Cases of marked chronic bronchitis as shown on examination and x-ray are also poor risks.

'*Hernia*: Hernia cases if not too large and disabling will be accepted.

'*Varicosities*: Severe varicosities with stasis pigmentation or edema are considered poor risks for general labor work.

'Since the latter part of January of this year we have taken routine blood Kahns on prospective employees. However, we pass the man for the job before the report of the blood Kahn is back, depending on the physical examination to rule out any infectious case. In the first six months, 1218 examinations showed a little over 50 positives which gives 4% positive results. In the event of finding a positive blood test the employee is called in for a private interview with the physician. He is not told he has syphilis, but is told that his blood report came back positive and is strongly urged to see his family physician for re-check examinations and therapy if indicated.

'This same policy is followed in any correctional defects which are discovered since we consider the pre-employment examination an essential part of our most important function, mainly attempting to keep the employee's health on the highest possible level.

'In conclusion I would like to reiterate that the pre-employment examination is for the purpose of hiring the man, not to reject him; that it is an important part of introducing the man to the company; and that it lays the ground work for our plans in the future medical care of the employee whether on the job or due to outside illnesses.'

Orientation of Employees and Co-operation of Medical, Engineering and Safety Departments

JOHN W. YOUNG, Supervisor of Safety, Harvester Company, stated that the industrial health program has always received management's complete and full support. He quoted Fowler McCormick: "If there is one thing we want it is a safe and healthy plant, proper light, heat, water and general working environment." Continuing, Mr. Young said: "Dr. Eugene L. Walsh, Dr. James A. Britton, Dr. Will F. Lyon, Dr. Harold H. Steinberg, and James R. Allan have all been a bulwark to us in our effort for provision of safe and healful conditions."

As a continuation of the attention given to health and safety on indoctrination of the new employee, after the completion of the physical examination, the man is referred to the safety department where the safety supervisor reviews the ideas and program of Harvester in these respects before he is referred to Job Instruction.

In the control of environmental exposures, a health hazard survey form is filled out by the Engineering Medical and Safety Departments. Contact is maintained with changing operations through the system of having these three departments notified of the installation of new processes involving hazardous materials. Exhaust ventilation equipment is checked regularly every week by the Engineering Department to be sure that air velocities are up to a specifications. In each plant one man in this department

is designated to follow up this schedule, and in the large plants, two men. In order to be sure that the ventilation equipment is adequate when first installed, prints of the lay-outs are submitted to the Engineering Department at our general office for approval, after which they are rturned to the p'ant for installation.

An example of the coordination of the Safety Department with the Medical Department in the control of an occupational disease problem is the action taken on the war-time use of paint with lead content. Dr. Steinberg requested that we check this exposure in the plant. It was found that well-ventilated spray booths were in use, but that the ends of trucks being sprayed extended outside the booth. In order to determine whether this condition resulted in excessive lead exposure, Dr. Steinberg asked for urine samples. These were collected and an analysis showed sufficiently high lead to indicate that these spray painters were being exposed to more lead than was desirable. Based on these results, additional control measures were considered justified. After these were instituted, further urine samples were analyzed and found to contain only the amounts of lead which might be expected where lead exposures are within safe limits. The hazard was thus brought under control before actual injury to health occurred.

Industrial Nursing Program

Miss Jean Fowler, R. N., Supervisor of Nursing, discussed the industrial nursing program.

'In presenting the high points of the Harvester industrial nursing set-up, it is necessary to note the extent of the Harvester operations. In Chicago there are six plants, each one employing from 1000 to 7500 workers. In other parts of the country there are some 17 additional p'ants. In each of the large plants there are 10 to 12 nurses with one head nurse, one visiting nurse and staff nurses. We now employ throughout the country 84 nurses, all R.N's, each working 40 hours a week.

'Each plant has its own particular line of products to manufacture and necessarily, the first-aid set-up is more or less designed to meet each particular requirement. For instance, the steel mills involve large masses of molten metals and huge rolling mills, from which injuries can be very severe. They operate 24 hours a day, seven days a week. Iron and coal mines require another type of operation. Foundries are in another class. Machining operations constitute still another type. And even in our twine mill, a special problem exists — that of acne and dermatitis. Thus, it is necessary that our nurses be trained so that they can handle any situation which may arise in the plants to which they are assigned.

'Some of our plants have added new equipment in recent years, and we find that our nurses have to be trained in laboratory work and x-ray technique. By means of improved facilities, we have been able to give our employees the best of care in our dispensaries.

'In the successful operation of our health program, we observe close cooperation with every department concerned with industrial relations. With such close contact, we are able not only to take care of employees who have suffered some injury, but we exert positive influence in maintaining improved health levels.

'The profits resulting from our work do not show up as such in reports to stockholders, though we believe that a substantial ultimate profit in dollars and cents accrues to Harvester from our work. Our records showing that we have saved many eyes, legs, and lives are the profits with which we are immediately concerned.'

The Visiting Nurse Functions

Mrs L. V. Cooney, R.N., visiting nurse of the McCormick Works, in describing the functions of the visiting nurse at the International Harvester Company, stated: 'These are principally to visit the employees who are ill or in need who do not report to the Plant Physician. Actual nursing care is not given un'ess the case is a plant accident. Symptoms and possible duration of all illness are recorded and reported to the plant physician and Employees' Benefit Association.

'In visiting these homes many incidents come to the attention of the nurse. Frequently simple nursing procedures are taught to some member of the family to make the patient more comfortable. A seriously ill patient, not having a physician, is advised to call one, or is referred to a dispensary.

'Sometimes the trouble is a financial one. The wage earner's lowered income or loss of income during illness is a serious thing

in some families. Local funds are at our disposal, and emergency aid is given until such a time as the proper agency is functioning on the case.

'Some time ago I visited a home and found the man's wife more seriously ill than he was. The Plant Physician was consulted and he suggested that we have her come in for an x-ray. This was done and she was found to have an advanced case of tuberculosis. Her husband was called in and told about her condition and given the x-rays to show his family physician. The physician confirmed the diagnosis, and arrangements were made for her at the Municipal Tuberculosis Hospital. The husband and children were examined and found free of T.B. After the mother went to the hospital, provision was made for the care of the rest of the family.

'A little different type problem was that of the family of one of our men at another plant. The Juvenile Court called the plant to see if they could contact the man because his children were being kept out of school so frequently and the home conditions were bad. I visited the home and found the mother with seven children and expecting another in a month. The house was filthy. There were only two beds and a davenport very little bedding, no sheets, not even a pillow. The gas was shut off and the electricity was about to be shut off. The children were in need of all kinds of clothing — one of the reasons they were kept home from school.

'The case was reported to the nurse at the plant, and through their Goodfellow Club the light and gas bills were paid and beds, bedding and clothing for the children were sent out. Mr. "X" was given some paint for the kitchen, and when I visited there later Mrs. "X" showed me the house with great pride. The kitchen had been scrubbed and painted and the house was very orderly. The Chicago Maternity Center sent a layette for the new baby, whom they delivered.

'Besides visiting the sick and needy at McCormick Works, health habits are taught to the women employed in the plant: restrooms are planned, furnished and inspected. We have Christmas funds and camp funds at our disposal, and the visiting nurse is expected to know what families are most deserving of help. Company policies and the amount of benefits are explained to the employees.

'The Visiting Nurse's job is never monotonous. It reveals tragedy and humor — as the time I went to visit an old darky who opened the door, bowed to the waist and said, "I am highly honored to have you visit my home, Mrs. McCormick."'

Environmental Surveys of Potential Health Hazards

DR. J. A. HUBATA, formerly physician-in-charge at the West Pullman Works, has conducted a complete environmental survey of potential health hazards at this plant in conjunction with Mr. R. D. Wood, safety supervisor of the plant. The data are presented on specially prepared 12in. x 15in. charts and include reference both to exposures and to control measures.

The foreman of each department in the plant is given a report on the hazardous materials incident to the processes under his direction, together with their physical and chemical properties, also signs and symptoms of impending effects on health as well as first aid treatment of an acute poisoning.

With such forthright handling of the health hazard situation, the specter of the unknown is dispelled and employee relations can be placed on a more secure basis in so far as complaints and greviences on hazardous environment are concerned.

Control of Lead Exposure

DR. A. SLIVE, physician-in-charge at the Tractor Works, discussed methods of control of the lead exposure at this plant.

'Although the incidence of lead poisoning in industry has decreased during the last two decades' he stated, 'it continues to be a very serious hazard. Because the active treatment of plumbism is so unsatisfactory, the intelligent application of preventive measures is necessary.

'The Tractor Works has 50 men working in occupations involving potential lead exposures. Eighty-five percent of these men work in the Radiator Manufacturing Department as iron-solderers, torch-solderers and dip-solderers. One man works a large induction heating heating unit that solders automatically, and another is an attendant for two lead pots used in case-hardening steel shafts.

'All new lead workers hired receive the usual pre-employment physical examination, including history of previous lead exposures, chest x-ray, Kahn test, and routine urinalysis. Subsequently, each man is called in twice annually for a urine lead determina-

tion. It is wise on these occasions, also, to do a periodic physical examination, paying particular attention to such subjective symptoms as weakness, weight loss, constipation, abdominal colic, anorexia, vomiting, insomnia, and headaches. Physical examination should detect the presence of lead line, extensor weakness of wrists, malnutrition, abdominal tenderness, hyperactive biceps and patellar reflexes, tremor, and pallor.

'Two such examinations a year are adequate provided that air analysis discloses less than 1.5 mg lead per 10 cubic meters of air. Because the chief source of lead which causes absorption is by inhalation of contaminated air, rather than by ingestion, it is quite feasible to express the amount of lead hazard in terms of lead content of the air samples. I regret to confess at this time that we have not had any air analysis performed, but plan to do so as soon as we have our own new industrial hygiene laboratory set-up. It must be remembered, however, that air analysis will not aid the physician in diagnosing an incipient case of lead poisoning due to ingestion.

'Blood changes of a biologic nature, such as anemia, reticulocytosis, and basophilic stippling are too non-specific and variable to be reliable. A lead line also may be simulated by any metal which can cause the deposit of a black sulfide in the gum. It is fortunate that the pathogenesis of chronic plumbism is such that the disease is always preceded by a stage of lead absorption. We, therefore, believe that periodic studies of lead absorption in the individual worker are the most important single diagnostic measure in detecting plumbism in its incipient stages. Stool analyses for lead do not give a true picture of absorption because part of the lead found is ingested and part absorbed. Only blood or urine lead determinations are an accurate estimate of absorption, and because urine examinations are so much simpler and more practical than blood, we utilize the former method.

'The important factor in urinary lead determinations is the avoidance of contamination of the urine specimen. The specimen bottles are sent to the plant dispensary by the Laboratory of Polarographic Analysis in Chicago. We label the bottles with the workers' names and check numbers, and send them to the office of the department foreman. I have instructed the foreman to hand out the bottles to the workers after they have completed the day's work and changed clothes. If the man has not taken a shower at the plant before leaving, he certainly should at home that night. The following morning he pasess a specimen of urine into the container, and delivers it to the plant dispensary before he reports to the shop. We send all the specimen bottles back to the laboratory and in a few days receive its report. As lead is almost ubiquitous, great care is important in collecting the specimen.

'A separate chart or graph is kept on each employee. On this chart the concentration of urinary lead is plotted against time. A glance at the curve reveals whether or not the individual's lead absorption is within normal limits, and also whether it is increasing or decreasing. The urine of most North Americans contains an average of 0.03 mg. lead per liter. The upper limit of safe lead exposure as measured by urinary lead excretion is represented by a mean value of 0.10 mg. lead per liter. Concentrations of 0.15 mg. should not be exceeded frequently, and concentrations of 0.20 mg. rarely. It has been proved that several spot specimens of urine are just about as accurate at 24-hour specimens. If concentrations over 0.3 mg. are present, and contamination has been ruled out dangerous conditions of lead exposure are present. Whenever urine lead values are above the safe zone, the employee's working environment and personal hygiene should be investigated. Proper preventive measures can then be instituted to cut down the amount of exposure.

'During the past four years, the labor turnover among our lead workers has been high, amounting to about 70%. I have graphed, by superimposition, the urine lead concentration curves on a single chart, of the 15 solderers who have been with us all of this time. The results are rather interesting. From January, 1943, to January, 1945 it is seen that there are many abnormally high values. From January, 1945, to the present time it is observed that all of the concentrations fall into the safe range. This uniform decrease in lead absorption certainly indicates decreased exposure. The explanation may be in any or all of these reasons: Decrease in working hours, changing to solder containing more tin and less lead (tin increased from 20% to 35%), and the substitution of the induction heating unit for nine hand iron-solderers.'

Engineering Control Measures

For many years, the engineering control of health hazards and nuisance conditions has been under the supervision of Mr. James R. Allan, manager, Industrial Engineering and Construction Department, and formerly President of the Chicago Section, American Industrial Hygiene Association. Although other duties prevented Mr. Allan from participating in this presentation of the Harvester industrial health program, it is well known that progressive engineering control measures have been instituted under his direction throughout the Harvester plants. For example, where many engineers felt that it might be good enough to recirculate air from a silica dust operation through a collector back into the plant working areas, Mr. Allan repeatedly stipulated that such air should not be re-used on the basis of his broad personal knowledge of actual operating conditions.

Industrial Accident and Claims Handling

Mr. Cass G. Gregory, manager, Industrial Accident Department, observed that occupational disease claims constituted a very minor part of their work due to fine preventive work of the Medical, Safety, and Engineering Departments. Occupational diseases are reported to the supervisor and then to the Medical Department. The visiting nurse or the plant physician visits the disabled worker and, if the disability is considered to be occupational, a report is referred to the manager of the accident department.

During the calendar year 1944, a total of 76 dermatitis cases were reported to this department, of which 30 involved lost time beyond the statutory waiting period; eight claims of silciosis, with payment being made on only five as true occupational disabilities; and nine other claims on which payment was made in only two cases.

In 1945, 58 dermatitis cases included 19 with lost time; payment was made on three silicosis cases; and on the 36 claims for all other occupational disease cases, payment was made on only five as true cases.

Future Plans

Dr. Eugene Walsh Assistant Supervisor of the Medical Services of the entire Harvester organization, summarized the elements of the successful industrial health program and indicated something of future plans for furthering the health of members of the International Harvester Company.

While under the over-all direction of Dr. Will F. Lyon, Supervisor of Medical Service, each plant is generally autonomous in its medical program. In the past, there has been largely a purely clinical approach to health problems. Although this tells much, modern scientific methods contribute additional data in handling specific problems. A new department is consequently to be launched by the International Harvester Company which will include an occupational disease research laboratory. Means will be provided for the scientific evaluation of potential health hazards through such methods as air analysis which have proved their worth in economic and effective control in many industries.

It is considered that the present effective industrial health accomplishment is a tribute to the vigorous approach to the problem by the well-coordinated activities of the Medical, Safety, and Engineering Departments.

Michigan Section

On February 19, the Section was addressed by Dr. Louis Schwartz of the U. S. Public Health Service on the subject of industrial dermatitis. Dr. Schwartz drew on his extensive experience as Head of the Office of the Dermatological Investigations in his presentation of the subject.

Chicago Section

The January 15 meeting was addressed by Mr. Theodore F. Hatch, Head, Membership Relations, Industrial Hygiene Foundation and President-Elect of the American Industrial Hygiene Association, on the subject "Appraisal of Dust Exposures in Relation to Silicosis."

The subject of industrial dermatitis was covered in the meeting held February 19, 1947. Maurice Dorne, M. D., Dermatologist, presented the medical phases and Kenneth M. Morse Acting Chief of the Division of Industrial Hygiene, Illinois State Public Health Department, the engineering methods of control.

On March 19, Clayton G. Loosli, M. D., Director, Student Health, University of Chicago, discussed "The Problem of Evaluating the Use of Air Disinfecting Techniques in the Control of Upper Respiratory Infections."

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